

1 Attorney Docket No. 82679

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3 HIGH-SPEED SUPERCAVITATING UNDERWATER VEHICLE

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5 STATEMENT OF GOVERNMENT INTEREST

6 The invention described herein may be manufactured and used
7 by or for the Government of the United States of America for
8 Governmental purposes without the payment of any royalties
9 thereon or therefor.

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11 BACKGROUND OF THE INVENTION

12 (1) Field of the Invention

13 The invention relates to high-speed underwater vehicles, and
14 is directed more particularly to supercavitating vehicles which
15 move in a cushion of air underwater.

16 (2) Description of the Prior Art

17 Recent investigations into high-speed underwater vehicles
18 have focused attention on providing vehicles which ride a cushion
19 of air to achieve high speeds in water. For a nominal prior art
20 streamlined, fully-wetted underwater vehicle, 70% of the overall
21 drag is skin friction drag; the remainder is pressure or blockage
22 drag. Supercavitation allows for much higher speeds to be
23 sustainable by eliminating, or drastically reducing, skin
24 friction drag at the higher speeds. The conditions for
25 supercavitation require that enough energy be put into the water

1 to vaporize a given volume of water through which an object can
2 travel. This is done by accelerating fluid over a sharp edge,
3 usually the nose of a vehicle, such as a torpedo, so that the
4 pressure drops below the vapor pressure of water. If the speed
5 of the object is not fast enough to travel through the vapor
6 cavity before the cavity collapses, artificial ventilation into
7 the cavity can keep the cavity "open" until the object moves
8 past. When a cavity completely encapsulates an object, by
9 vaporous and/or vented cavitation, it is referred to as
10 "supercavitation". The vehicle nose, or "cavitator", is the only
11 part of the object in constant contact with the water through
12 which the vehicle travels. The cavity closure is positioned
13 behind the vehicle.

14 When the cavitator and artificial ventilation generate the
15 necessary cavity properties, i.e., sufficient length and diameter
16 of air cushion, it results in a larger air gap between the
17 vehicle and water than is otherwise necessary at the after end of
18 the vehicle. The air, or other selected gas, is drawn through
19 the gap by a propulsion jet plume, and escapes into the ambient
20 water.

21 It has been found desirable to minimize the downstream
22 entrainment effect of the propulsion plume, to thereby minimize
23 loss of air and to increase life expectancy of a reservoir of
24 ventilation air on-board the vehicle.

SUMMARY OF THE INVENTION

1 An object of the invention is, therefore, to provide a high-
2 speed underwater supercavitating vehicle in which the air cavity
3 at the aft end of the vehicle is reduced while the air cavity
4 otherwise remains appropriately sized and configured for vehicle
5 travel.

6 With the above and other objects in view, as will
7 hereinafter appear, a feature of the present invention is the
8 provision of a high-speed supercavitating underwater vehicle
9 comprising an elongated hull of circular cross section, the hull
10 having a cavitator at a forward end thereof and means for
11 ventilating gas to form a cavity around the hull in underwater
12 travel, and an expandable annular skirt fixed on the hull and
13 having an outer surface generally contiguous with an outer
14 surface of the hull. The skirt is expandable to increase a
15 diameter of the skirt from slightly above a diameter of the hull
16 to proximate a diameter of the cavity, to define an annular gas
17 film between the expanded skirt and a boundary of the cavity,
18 whereby to substantially reduce the flow of gas from a forward
19 high pressure zone to an after low pressure zone.

20 The above and other features of the invention, including
21 various novel details of construction and combinations of parts,
22 will now be more particularly described with reference to the
23 accompanying drawings and pointed out in the claims. It will be
24 understood that the particular device embodying the invention is

1 shown by way of illustration only and not as a limitation of the
2 invention. The principles and features of this invention may be
3 employed in various and numerous embodiments without departing
4 from the scope of the invention.

5 6 BRIEF DESCRIPTION OF THE DRAWINGS

7 Reference is made to the accompanying drawings in which is
8 shown an illustrative embodiment of the invention, from which its
9 novel features and advantages will be apparent, wherein
10 corresponding reference characters indicate corresponding parts
11 throughout the several views of the drawings and wherein:

12 FIG. 1 is a perspective, broken away view of one form of
13 underwater vehicle illustrative of an embodiment of the
14 invention;

15 FIG. 2 is a diagrammatic side elevational view of the
16 vehicle of FIG. 1 shown underwater;

17 FIGS. 3a and 3b are perspective views of alternative embodi-
18 ments of skirt portions of the vehicle shown in FIGS. 1 and 2;

19 FIGS. 4a and 4b are perspective views similar, respectively,
20 to FIGS. 3a and 3b, but showing the skirt portions expanded; and

21 FIG. 5 is a sectional view of an alternative skirt portion
22 of the vehicle.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, it will be seen that an illustrative underwater vehicle 20 includes an elongated hull 22 of circular cross section. The hull is provided with peripheral grooves or apertures 24 for venting gas, typically air, under pressure stored in the vehicle. The hull 22 is provided with a cavitator shown herein as a pointed nose cone 26 at its forward end. The hull 22 contains a reservoir of gas under pressure for venting through the grooves 24, and a jet engine for propelling the hull 22 forward at a rapid rate. The after end of the hull 22 is open to accommodate a jet plume 28 (FIG. 2) when the jet engine is in operation.

An expandable annular skirt 30 is fixed on and around the hull 22. In a non-expanded condition, the skirt 30 extends substantially coextensively with the hull outer surface, the inside diameter of the skirt being substantially equal to the outside diameter of the hull 22. The skirt 30 is a relatively thin sheet of elastomeric material and adds little to the overall outside diameter of the vehicle.

The skirt 30 is expandable, as by the flow of pressurized gas through apertures 32 (FIG. 2) into a region 34 between the outer surface of the hull 22 and the inner surface of the skirt 30.

Referring to FIG. 2, it will be seen that the forward movement of the vehicle 20 causes the nose cone 26, which acts as

1 a cavitator, to create a cavity 36, or vapor region, behind the
2 cone 26. The outflow of pressurized gas from the grooves 24
3 enlarges the cavity 36 and maintains the cavity such that the
4 water-gas interface, or cavity boundary 38, is spaced from the
5 vehicle 20, except at the nose cone 26. Thus, the vehicle 20 is
6 not subjected to the friction of water, except at the nose cone.

7 Without the skirt 30 herein described, the jet plume 28
8 draws the gas surrounding the vehicle into the plume 28 very
9 quickly, thereby causing the gas reservoir in the hull to be
10 quickly exhausted, thereby shortening the range of the vehicle.

11 However, the skirt 30, when expanded, occupies almost all of
12 the gas cavity 36 forward of the jet plume 28, leaving only an
13 annular thin film 40 of gas around the skirt, as shown in FIG. 2.
14 The gas cavity forward of the skirt becomes a high pressure zone
15 and the gas cavity aft of the skirt becomes a lower pressure
16 zone. The gas in the forward zone escapes at a much lower pace,
17 holding its pressure for a longer time, maintaining the cavity
18 for a longer time, and thereby affording a substantially
19 increased range for the vehicle.

20 In a preferred embodiment, illustrated in FIGS. 3a and 4a,
21 the skirt 30 is pleated. The pleated structure, in addition to
22 the elastomeric material of the skirt, provides the skirt with a
23 relatively wide range for expansion. In another embodiment shown
24 in FIG. 3b and FIG. 4b, skirt 30 is made from annular bags 36a,
25 36b and 36c. As shown in FIG. 3b, bags 36a, 36b, 36c overlap one

1 another when deflated. Each annular bag 36 has an associated gas
2 supplying aperture 32 providing redundancy in case of bag
3 failure. In addition, the skirt may include discrete
4 compartments 34, as shown in FIG. 5, each compartment having a
5 gas supplying aperture 32 therein, such that damage to the skirt
6 in a given area does not necessarily cause failure of a mission.

7 The vehicle 20 may be provided with fins 42 mounted on the
8 hull 22 and adapted to extend beyond the cavity 36 for purposes
9 of stabilization and/or guidance.

10 There is thus provided an underwater vehicle having facility
11 for high-speed movement underwater and having means for
12 maintaining an air cavity, or cushion, through which the vehicle
13 moves, to reduce the rate of consumption of ventilation gas
14 stored on the vehicle, and thereby increase the range of the
15 vehicle.

16 It will be understood that many additional changes in the
17 details, materials, and arrangement of parts, which have been
18 herein described and illustrated in order to explain the nature
19 of the invention, may be made by those skilled in the art within
20 the principles and scope of the invention as expressed in the
21 appended claims.